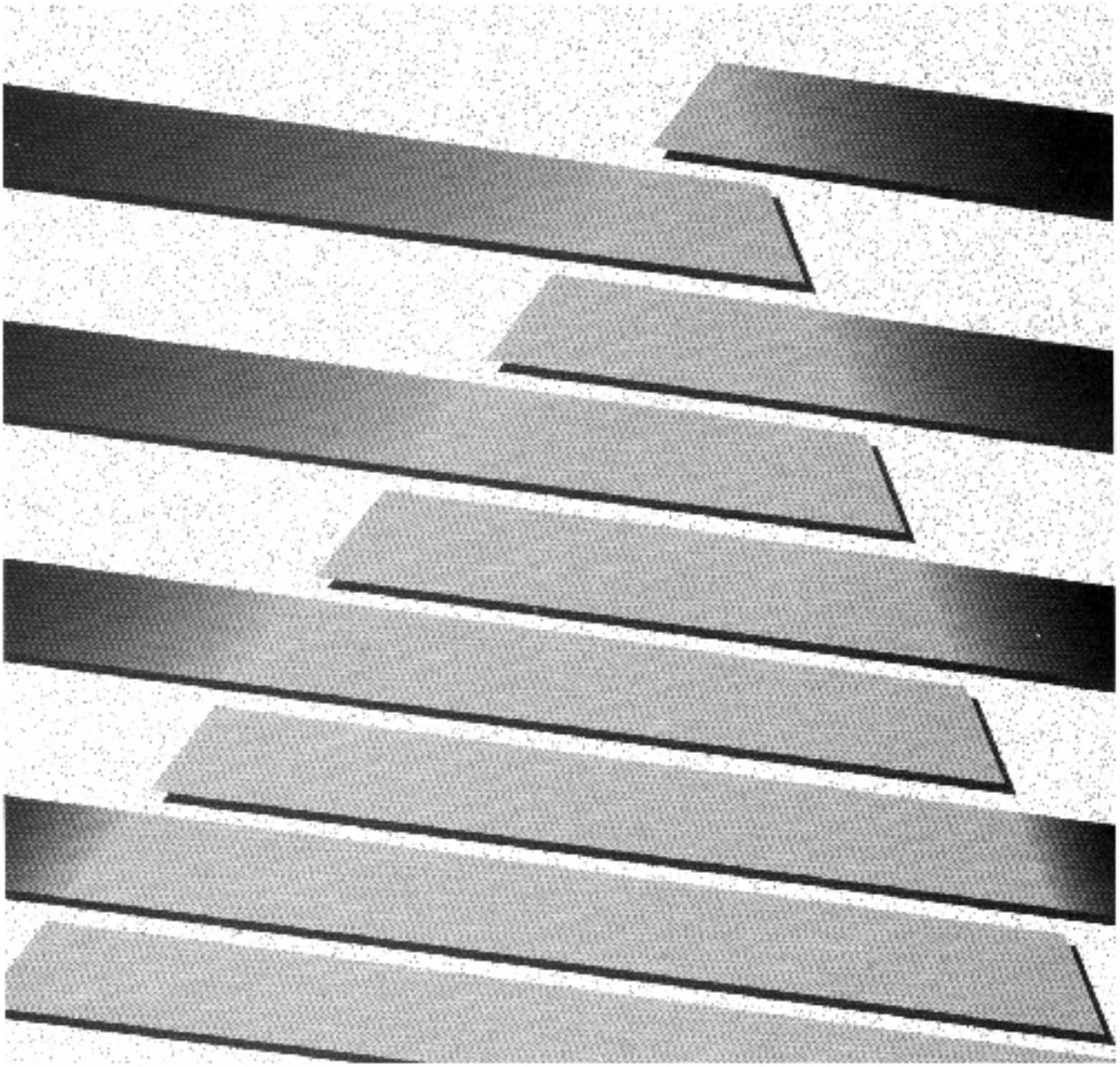
ALLEN-BRADLEY

Allen-Bradley I/O Scanner Module For IBM® Personal Computers

(Cat. No. 6008-SI)

Product Data



Important User Information

Because of the variety of uses for this product and because of the differences between solid state products and electromechanical products, those responsible for applying and using this product must satisfy themselves as to the acceptability of each application and use of this product. For more information, refer to publication SGI–1.1 (Safety Guidelines For The Application, Installation and Maintenance of Solid State Control).

The illustrations, charts, and layout examples shown in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, Allen–Bradley Company cannot assume responsibility or liability for actual use based upon the illustrative uses and applications.

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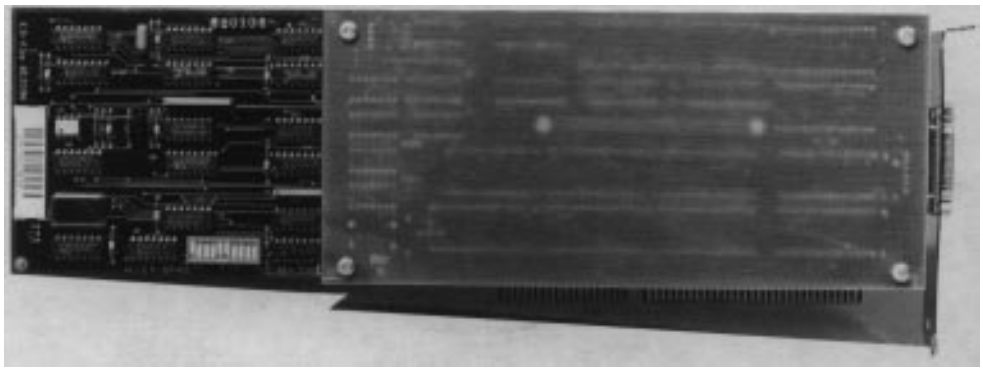
PC I/O Scanner Overview

The Scanner's Role

A scanner is a communication interface module that plugs into a host computer system. The PC I/O Scanner allows an IBM® personal computer (PC) direct access to Allen-Bradley universal I/O products via the remote I/O link. Through an adapter, the PC I/O Scanner can communicate with a wide variety of Allen-Bradley I/O modules to access:

- digital inputs/outputs
- analog inputs/outputs
- motion control
- process controllers (PID loop controllers)
- operator interface
- distributed Programmable Controllers
- machine vision processors
- special function modules

Figure 1.1
PC I/O Scanner



Benefits

Easy to install. A single twisted-pair cable for I/O communications can replace bundles of I/O ribbon cables. A single interface board can replace multiple I/O boards.

Host software support. The scanner comes with software libraries that are linked to your application program. The libraries allow faster program development through the use of functions specific to Allen-Bradley I/O.

Enhances system I/O performance. The PC I/O Scanner has its own communication processor, thereby offloading the main CPU from I/O tasks.

Compatible with a wide variety of Allen-Bradley I/O products. The PC I/O Scanner communicates across the Allen-Bradley universal I/O link to multiple adapters. (see Specifications)

Third party software availability. Third party software is available for the PC I/O Scanner. This allows you to program the scanner with easy-to-use graphics and menus, thus eliminating the need to know the C programming language.

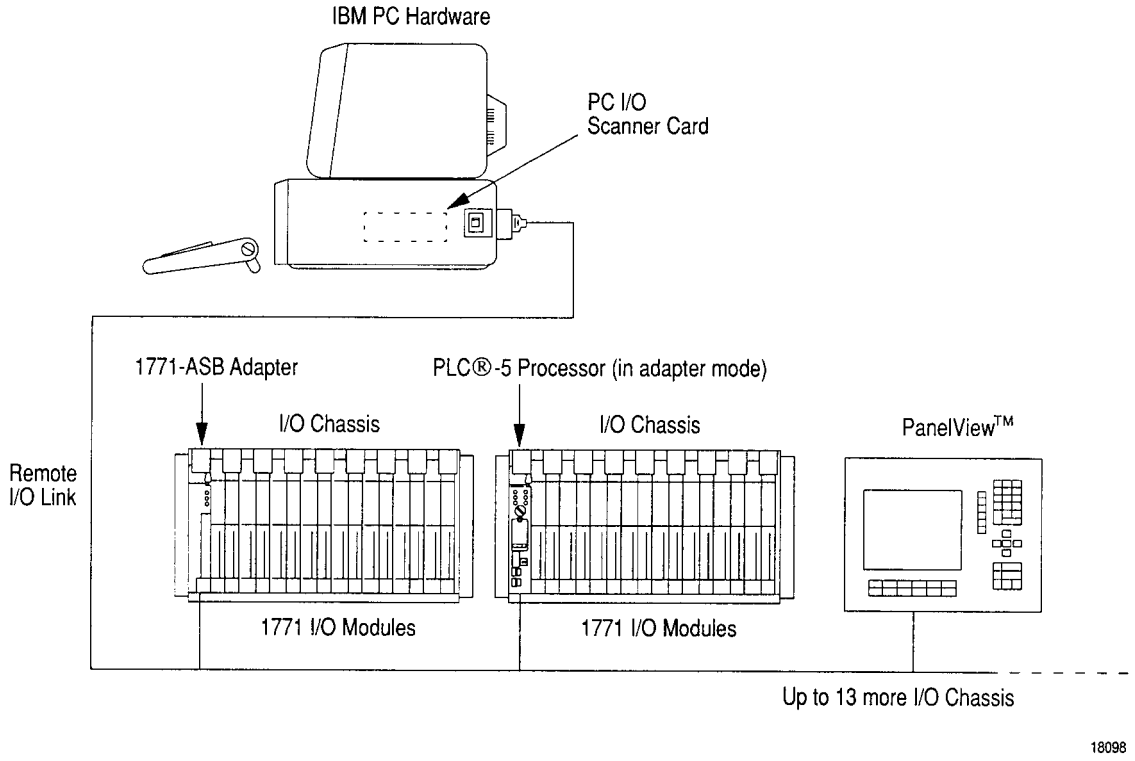
Chapter 2

Remote I/O Subsystem

How the I/O Subsystem Meets Your Application Needs

The Allen-Bradley PC I/O Scanner has a single port for an I/O link. You can connect up to 16 1771-I/O chassis or adapter devices to the scanner on the remote I/O link as shown in figure 2.1. The chassis are daisy-chained along a shielded two-conductor twisted-pair cable up to 10,000 feet in length. This remote I/O link lets you locate I/O modules close to monitoring and control devices of your system. I/O chassis are available in six sizes to hold up to 1, 2, 4, 8, 12, or 16 I/O modules.

Figure 2.1
A PC I/O Scanner Interfacing to an I/O Subsystem



Each 1771-I/O module can contain up to 32 inputs or outputs, which you connect to devices on your machine or process. When an application requires only a few I/O, use our single-point I/O modules.

The PC I/O Scanner's addressing capability allows you to configure the I/O chassis for a maximum of 8 I/O racks. Each I/O rack can have a maximum of 8 I/O groups. Each I/O group can have a maximum of 16 inputs/outputs. The I/O subsystem can be configured for a maximum of 1,024 inputs and/or outputs.

Each I/O chassis contains either an I/O adapter module or a programmable controller with which the PC I/O Scanner communicates. The I/O adapter transfers I/O data to and from its I/O modules across the chassis backplane. The programmable controller monitors and controls its I/O across the 1771-chassis backplane as a real-time distributed-logic processor. It transfers data to and from the scanner according to commands issued by the scanner.

Remote I/O Addressing

Your application program addresses I/O data in the scanner's dual-port RAM based on the location on the link of the corresponding I/O module. This is defined during installation by:

- I/O rack (0-7)
- I/O group (0-7) within the I/O rack

For discrete digital and analog I/O modules, the link location address of an individual input or output not only identifies the rack and group, but also the input or output within the I/O group.

An I/O group corresponds to a 16-bit word in the input image table and a 16-bit word in the output image table as shown in figure 2.2. By setting switches at each chassis, you select its addressing mode based on the density of the I/O modules you are using.

If you select	Then you have	With
two-slot addressing	two I/O module slots per I/O group	8 input/output bits per slot
one-slot addressing	each I/O module slot as an I/O group	16 input/output bits per slot
half-slot addressing	two I/O groups per I/O module slot	32 input/output bits per slot

Figure 2.2
Two-Slot I/O Group (a 16-bit input module and a 16-bit output module) and its Corresponding Output Word and Input Word

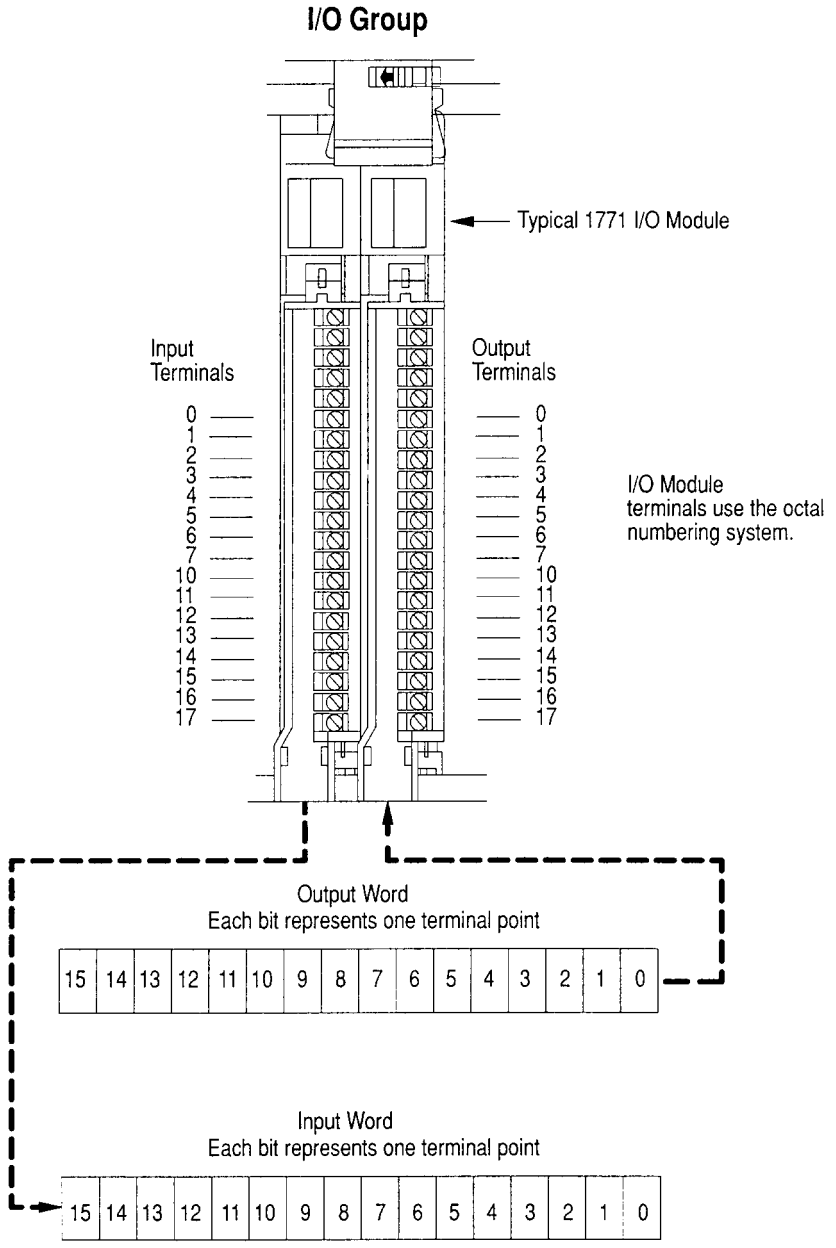


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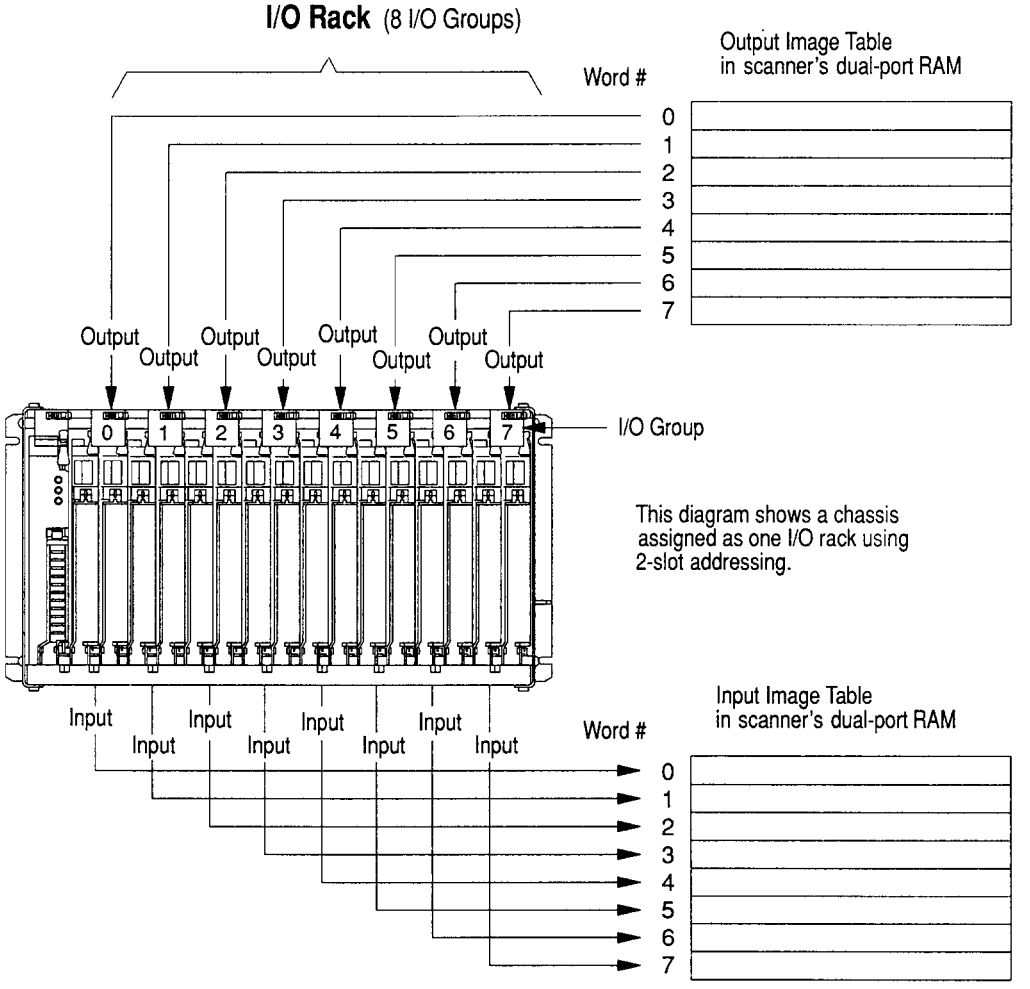
Figure 2.3 shows how you assign each I/O adapter an I/O rack number (0 to 7) by setting switches on the adapter.

An I/O rack is an I/O addressing unit containing a maximum of 8 I/O groups.

Figure 2.3
Typical 1771 I/O Chassis with I/O Modules Installed Showing the I/O Image and Corresponding Hardware for One Assigned Rack Number Using Two-Slot Addressing



Distributed Processing of I/O

Up to this point, we have discussed only direct control of I/O. Through a 1771-ASB or 1771-JAB adapter, the PC I/O Scanner directly monitors the status of input terminals and controls the status of output terminals.

The scanner also sends output status to and receives input status from a 1785 PLC-5 controller configured for the adapter mode or to a Direct Communication Module (1771-DCM) in an I/O chassis controlled by a PLC controller. To the scanner, the controller appears to be similar to an I/O chassis with a 1771-ASB adapter. However, the controller's application program controls the status of its output terminals and controls the status of the input data to the scanner.

While outputs are controlled by the controller in this type of configuration, the scanner provides supervisory control and monitoring. The program in the controller could, however, use output data from the scanner to directly control some outputs and send some input status

Chapter 3

PC I/O Scanner Operation

Main Components

Figure 3.1 shows the main components of a typical system:

host CPU — an IBM PC computer system that runs the application program and drives the scanner.

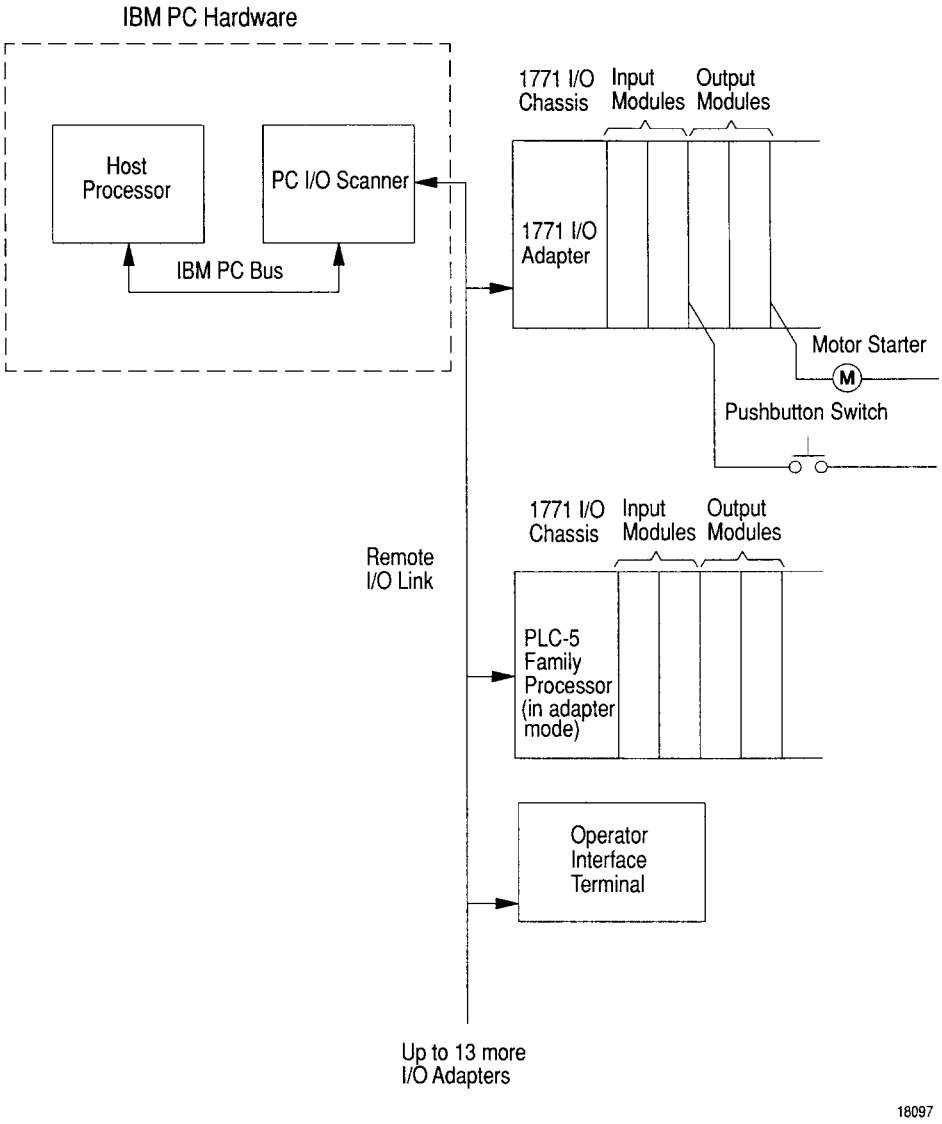
PC I/O Scanner — PC I/O Scanner (cat. no. 6008-S1) physically resides in the host computer system. The scanner is a full-length, double-width card and occupies two standard XT or AT slots. The Allen-Bradley I/O Scanner Module lets you connect an IBM personal computer (PC) to an Allen-Bradley 1771-I/O subsystem.

PCbus— the circuit board or backplane that the scanner plugs into.

I/O adapter — the device on the I/O link that communicates to the scanner. Up to 16 adapters can connect to one scanner.

remote I/O cable — a twinaxial (shielded two-conductor twisted-pair) cable that connects the scanner card to each adapter in the I/O subsystem. Allen-Bradley recommends Belden 9463 cable.

Figure 3.1
Scanner's Main Components



Link Operation

No direct communication exists between the host CPU and the I/O; rather the host CPU communicates with the I/O image table of the scanner's dual-port RAM. Input status is read from the input image table and outputs are written to the output image table of the scanner's dual-port RAM.

Data Transfer Methods

Data transfer is the movement of data to or from I/O modules. There are two types of data transfers:

- Single transfer is the exchange of a single unit of data (8, 16, or 32 bits) to or from each I/O module in an I/O chassis. A single transfer occurs during each scan of an I/O adapter.
- Block transfer is the exchange of up to 64 words in a particular direction between a scanner and an I/O module. The scanner initiates a block transfer as a one-time event.

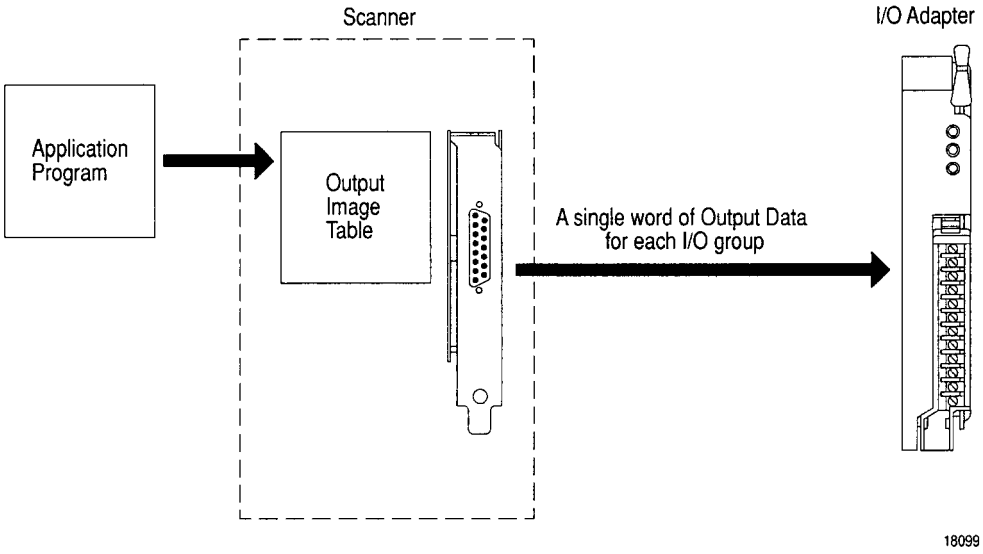
Asynchronous Scanning

The data transfers from the host CPU are asynchronous to the PC I/O Scanner's remote I/O update. Asynchronous means that the scanner continually reads from and writes to each I/O adapter independently of your application program.

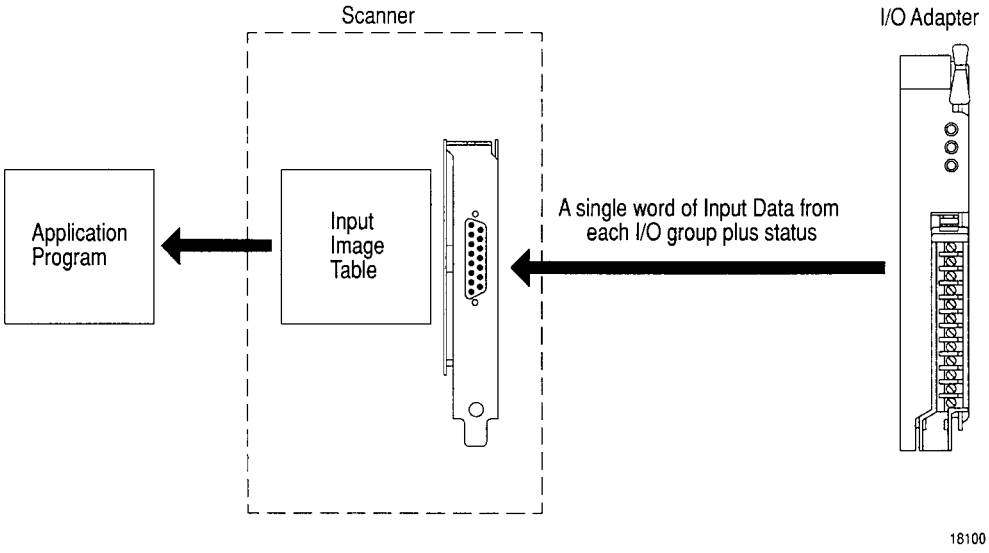
Scanning an Adapter

The scanner (master) polls each adapter (slave) on the I/O link in a circular scan list, which means that each time the scanner reaches the end of a list, it starts again at the beginning as shown in figure 3.3. To scan an adapter, at least two, and possibly three, events occur.

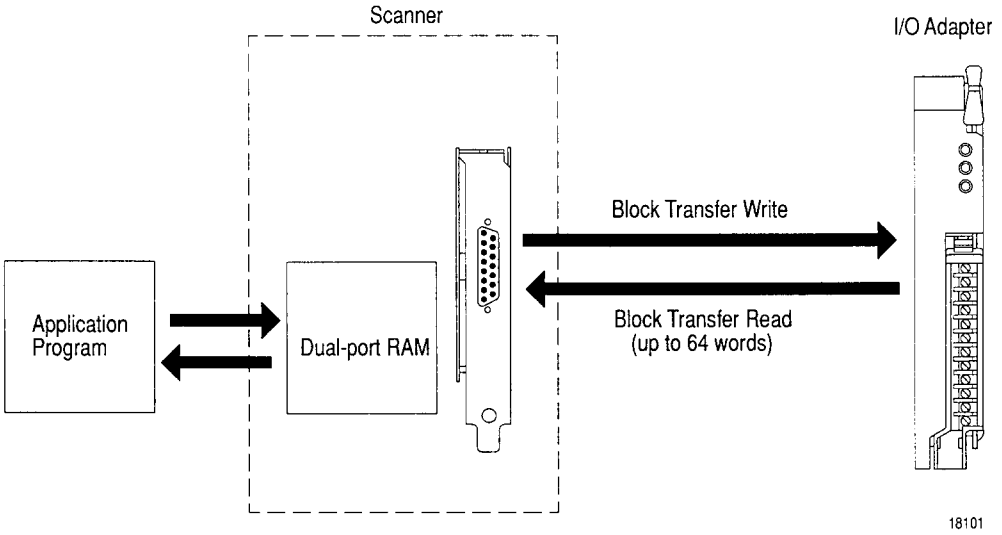
1. The output image table in the scanner's dual-port RAM contains output data that is sent to the adapter. The scanner sends out to the adapter a single 16-bit word of output data for each I/O group in the I/O rack.



2. The I/O adapter replies to the scanner with a single word of input data for each I/O group in the I/O rack. The scanner puts the data into its input image table. Along with the input data, there is a block-transfer status bit that tells the scanner whether a module in the I/O rack is ready to do a block transfer.



3. The scanner checks the block-transfer status bit to determine whether a block transfer should happen. Only one block transfer is allowed per rack per I/O scan. If the bit is set, the scanner performs the block transfer.



Determining I/O Scan Time

For each I/O rack, the nominal single-transfer time (the time it takes to update a single I/O rack) is 7ms at 115.2k bits/s or 10ms at 57.6k bits/s.

Each block transfer takes 5ms plus 0.2ms per word at 115.2k bits/s or 0.3ms per word at 57.6k bits/s. The total I/O scan time is the sum of the individual times.

Example: Consider an I/O subsystem set for 57.6k bits/s with 4 I/O racks and a block-transfer module in each I/O rack. For this example, each block transfer module requires a block of 25 words. The total I/O scan time is:

4 x 10ms	= 40ms
4 x 5ms	= 20ms
4 x 25 x 0.3ms	= 30ms
approximate I/O scan time	= 90ms

How the Host Accesses Remote I/O Data

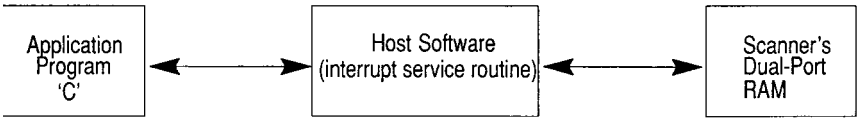
Remote I/O data is always available to the host CPU once the scanner is running. I/O data resides in the scanner's dual-port RAM.

Memory

The scanner's dual-port RAM has 6K bytes. The host CPU and scanner exchange control of this area by means of interrupts. When the scanner interrupts the host CPU, the scanner is turning over control of the dual-port RAM to the host. When the host CPU interrupts the scanner, the host either has the dual-port RAM and wants to return it or the host doesn't have the dual-port RAM but wants access to it.

For the host CPU, we supply an interrupt handler, or interrupt service routine, that is automatically invoked when the scanner interrupts the host. The interrupt service routine copies information as needed between your program's data area and the dual-port RAM as shown in figure 3.2.

Figure 3.2
Interrupt Service Routine Interfacing to Dual-Port RAM



Because the interrupt handler takes care of all details of the dual-port RAM, you needn't be concerned with the bits and bytes. You should know, however, that the dual-port RAM contains two areas of information:

- The I/O image tables, which are comprised of an output image table and an input image table. Each time control of the dual-port RAM is transferred, the interrupt routine copies new inputs from the dual-port RAM to your program's data area and new outputs from your program's data area to the dual-port RAM
- An area in which the host CPU sends commands to the scanner and the scanner returns confirmation and data

Data Paths

Input data follows this path:

- An external switching device closes a digital input circuit in an input module
- When next asked by the adapter, the input module reports the new input state. The adapter updates its internal input image table by setting the bit corresponding to the particular input
- At the next scan, the adapter reports the new input state to the scanner. The PC I/O Scanner updates the input image table in the dual-port RAM by setting the bit that corresponds to the particular input
- The host interrupt handler reads the input image information in the dual-port RAM and copies it to a duplicate input image table that is available to your program. Your program now knows that an input on a particular input module is ON

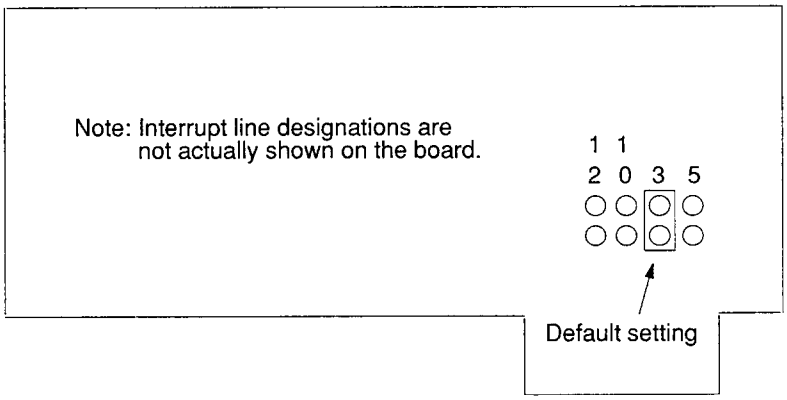
The path of output data is essentially the reverse of the input path:

- Your program sets a bit in its output image table. The program knows that this bit “maps” to an output on a particular output module
- The scanner interrupts the host. The interrupt handler copies your program’s output image for that rack to the dual-port RAM
- At the next scan of the adapter that controls that particular module, the scanner tells the adapter to update its output image table with the new state of the output
- The adapter tells the discrete output module the new output state
- The output module closes the digital output circuit. Any external device attached to the output is activated

Hardware Interrupt

On the system board, the scanner uses one of four interrupt lines as shown in figure 3.3. The interrupt line is selected with a jumper on the scanner board. The choices for the interrupt lines are 3, 5, 10, 12.

Figure 3.3
Four Interrupt Lines on the PC I/O Scanner



Choose an interrupt line that does not conflict with any other boards in your system. You cannot have two IBM PC I/O Scanners operating in the same host. The host software supports only single scanner systems.

Software Interrupt

The host receives interrupts from the scanner by default through line IRQ3, which corresponds to software interrupt number 0Bh. Results are unpredictable if you have any other software that uses that interrupt.

The scanner driver routines also use the timer follow-on interrupt, number 1 Ch. If the host CPU has resident software that uses that timer interrupt, execution of that software will be suspended while the scanner program is running and will probably resume if the scanner program executes the **stop_6008()** function. Print spoolers are the most common class of programs to use the timer follow-on interrupt.

The scanner doesn't use any host I/O ports.

How the PC I/O Scanner Operates

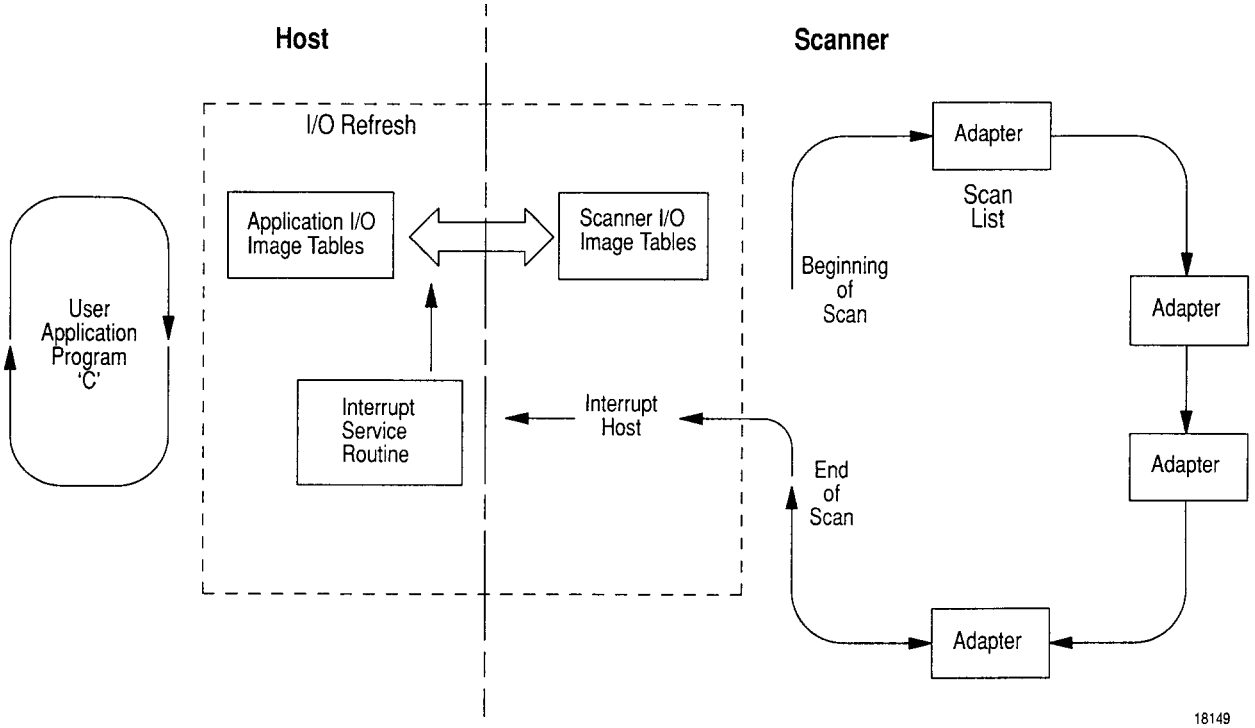
In relation to the host CPU, the scanner runs asynchronously. When either wants to get the other's attention, it issues a hardware interrupt. The host CPU and the scanner can postpone servicing an interrupt if it is already processing another interrupt task.

Scan List

The scanner maintains a scan list of adapters to be serviced by the scanner. An adapter may appear once, several times, or not at all in the scan list. The list starts simply with a list of adapters, each occurring once, but your program can issue a scanner command to alter the list.

An exchange, or an adapter scan, is the scanner's interchange of information with one adapter. During an exchange, the scanner receives data and status information from the adapter and sends data and commands to the adapter. The PC I/O Scanner performs a discrete transfer of I/O data during the same exchange. If the adapter's chassis contains a block-transfer module that is ready, a block transfer will be performed.

Figure 3.4
The Process of Refreshing the I/O image Tables During an I/O Scan



After servicing an adapter, the scanner looks at its command queue to see if any management commands are waiting. If so, and if the current operating mode allows, the scanner executes one management command. If the scanner had a confirmation of this command or of a previously executed command, it puts the confirmation in the dual-port RAM and interrupts the host CPU.

The scan list is circular. Each time the scanner reaches the end of the scan list, it starts again at the beginning. A scan is one complete cycle by the scanner through the scan list from any point to the same point.

Each time the host CPU interrupts the scanner, the scanner puts a marker in the scan list at the point of the adapter most recently scanned. If the scanner works its way through the scan list to the same point without receiving an interrupt from the host CPU, the scanner will interrupt the host. If the scan list contains no adapters, the scanner will wait for 5ms before interrupting the host CPU.

Thus, the I/O image tables are refreshed once per scan. Partial refreshing takes place more frequently if your program executes a lot of block transfers or management requests. Whenever the dual-port RAM is transferred, the I/O image tables are refreshed to the point of the scanner's advance in the list since the last interrupt.

Host Watchdog

In the event of a program crash, or your program gets into an infinite loop, there is no way for the interrupt service routine (ISR) to recognize all failures. But there is a host-watchdog scheme.

Essentially, your program must take a particular action every so often — by default, every second. If the ISR recognizes that the required action has not been taken recently enough, the ISR infers that your program has failed and stops talking to the scanner. The scanner recognizes that "quiet" as a host failure and goes off the link within 50ms. All the adapters go inactive, and output terminals go to either their last state or off as determined by switches you set on the adapters. Details of this feature are in the IBM PC I/O Scanner Module User's Manual, publication 6008-6.5.3.

Scanner Watchdog

If the host computer doesn't respond within 100ms to an interrupt from the scanner, the scanner assumes that the host program is no longer active. In this case, the scanner goes off the link, and 50ms later the adapters set the output modules in last state or off according to your switch settings. The scanner then goes into its power-up sequence, waiting for new start-up commands from the host CPU.

The scanner watchdog feature lets you end one program run and start another without cycling host power. Even if your program locks the host computer, if you are able to do a soft reset [Ctrl-Atl-Del], the scanner will be ready for your program. More importantly, if your program fails or is interrupted, even by a reboot of the computer, all discrete digital outputs will be in last state or off according to the switches you set on the adapters.

Application Development

Host Software

You will need the MS-DOS® or PC-DOS™ operating system, version 2.11 or higher. If you are using the Microsoft® C version of the scanner-driver software, you'll need a Microsoft C compiler, version 4.0 or higher. With the Lattice® C version of our software, you'll need a Lattice C compiler and linker, preferably version 3.10 or higher.

Here is a list of the host software:

H_6008SI.H — include file
6008SI*.LIB — run-time libraries
U_D1.EXE — user diagnostic program in executable form

The "include file" is copied to the area that contains other include files used with your compiler.

Run-time Libraries

The run-time libraries are copied into their own library directories. One directory for each memory model. Library routines allow I/O control and the issuing of commands.

setbit	setbit
setbyte	clrbit
setword	putbyte
putbit	putword

MR_WAIT is a function contained in the library that is used to issue management commands.

Commands for Configuring the Scanner

There are two types of scanner commands, block transfers and management requests:

Block transfers are:

- BLOCK TRANSFER READ
- BLOCK TRANSFER WRITE

Management requests are:

- SET MODE
- AUTOCONFIGURE
- SCAN LIST
- LINK STATUS
- SETUP
- FAULT DEPENDENT GROUP

A management request affects the operation of the scanner. The following table summarizes the function of each management request:

Command	Description
SET MODE	changes the scanner's operating mode to program, test, or run
AUTOCONFIGURE	goes on the link to see what devices are attached
SCAN LIST	changes the order in which adapters are scanned and their relative frequency
LINK STATUS	asks the scanner to report all information it has about the adapters that are connected
SETUP	changes the data-transmission rate and connects or disconnects the line-termination resistor
FAULT DEPENDENT GROUP	designates one or more groups of adapters in such a way that if one adapter in a group is faulted, the scanner will instruct the others to be faulted too

Code Example

The manual (IBM PC I/O Scanner Module User's Manual, publication 6008-6.5.3) contains many code examples identifying the different functions provided in the software libraries supplied with the scanner. Figure 4.1 shows the start of a sample program, with a call to **setup_6008** and associated checks for error.

Figure 4.1
Code Fragment Programmed in C

```
#include  <stdio.h>
#include  <h_6008si.h>
void main ( )
{

            QMR  pkt;
            int status;
            . . .
            status = setup_6008 (-1, -1, -1, 0xC400,  &pkt);
            if ( status != OK ){

                printf("setup failed: command=%s  status=%s\n",
                   xlat_cmd(status), xlat_conf(pkt.qmr_stat));
                if ( status != C_AUTOCONF && status != C_SETUP )
                   printf(scanner fatal error %d\n", fatal_6008( ));
                abort( );

            }
else
   mr_print(stdout, C_AUTOCONF, &pkt);
. . .
```

User Diagnostic Program

You must know how to start a program under DOS to run the scanner's diagnostic program. You can run the diagnostic program even if the I/O cable is not attached.

We provide the source files of the diagnostic program on either a 5.25" or 3.5" diskette so that you'll have extended examples of successful programming for the scanner. You should feel free to experiment by modifying them, although we cannot support any modified program versions. We also include an executable version of the diagnostic program so you can turn on the scanner.

Please note that all of the files on disks are copyrights of Allen-Bradley Company, Inc. and may not be distributed or copied without our permission, other than from the distribution disk to your hard disk or working disk.

Diagnostic Source Code Example

The remaining files whose names begin with **U_** make up the source code for the user diagnostic program. The files provide examples of how to control and how to get information from the scanner. The executable form of these files, **U_D1.EXE**, is a useful tool in testing the operation of the scanner interactively through the keyboard. The **U_D1** program can initiate every possible command the scanner can do. It should be the first program that is run after the scanner is installed in your PC.

U_D1.C	main program
U_D1.H	include file for the U_*.C files
U_BT.C	single block transfer
U_BTC.C	continuous block transfers
U_BTM.C	multiple block transfers
U_DISC.C	full-screen discrete I/O
U_GET.C	keyboard handler
U_GROUP.C	single-group discrete I/O
U_MR.C	management requests
U_PICK.C	main menu

Appendix A

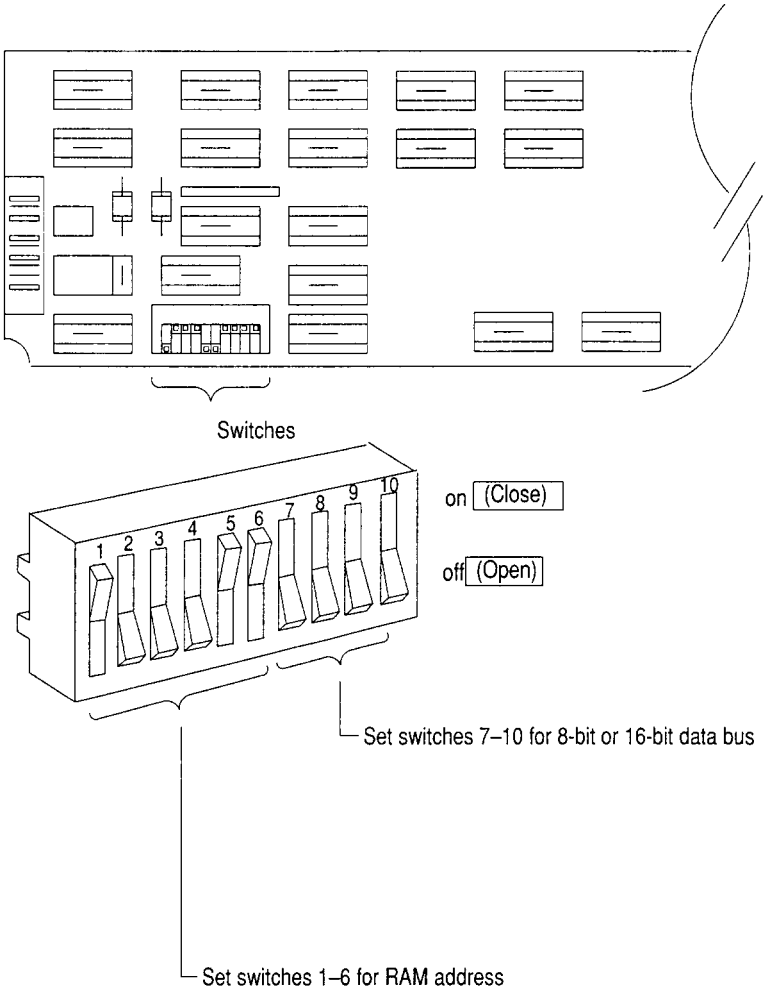
Scanner Installation

You'll complete these main steps to install a scanner module in the host CPU:

- set the card's switch block for the memory address you selected earlier
- choose the interrupt-request line the board will use with a jumper
- plug the scanner into the expansion slots in the host
- connect the I/O cable to the scanner

The scanner card has one block of ten switches to be set at installation time as shown in figure A.1. For a complete listing of switch settings, refer to the IBM PC I/O Scanner Module User's Manual, publication 6008-6.5.3.

Figure A.1
PC I/O Scanner Showing Switch Settings



RAM Address

Figure A.1 shows switches 1 thru 6 set for memory address C0000h for an IBM PC/AT or another machine with a 16-bit bus. If you're running on a PC/XT or another 8-bit bus machine or if you want to configure the scanner at an address other than C0000h, you must change the switches.

These switches let you configure it to any starting address in RAM, from 04000h to FC000h, in increments of 4000h = 16Kbytes. (The scanner cannot be configured to operate in extended or expanded memory.) The scanner card will occupy 1801h (6K + 1) bytes beginning at the address you select. You must select an address that starts a free 6K + 1 byte range.

Avoid selecting a RAM address range that conflicts with other third-party board addresses; otherwise, you'll overwrite the memory areas of the third-party boards.

Plugging in the Card

The scanner card requires two adjacent slots in the host's backplane (although there is just one row of connectors), but you can use any full-length two-slot area you choose. Install the card with mounting screws to maintain proper seating.

The scanner has a 15-pin male connector that is accessible through the back or side of the host computer. The remote I/O cable terminates in a 15-pin female D-shell connector, which is supplied.

Specifications

PC	Minimum PCbus Hardware Configuration	▪ a standard AT or XT bus configuration
	Power Requirement	▪ 2.5 Amps
	Card Size	▪ two-slot full-length card
	PCbus Interrupts	▪ Select one of four levels (3, 5,10,12)
	Scanner Configuration	▪ Place only one scanner per PC in your computer system
	Memory Requirement	▪ 6K bytes of RAM within the system memory area
Environmental	Conditions	▪ Operating temperature: 0 to 60°C (32 to 140°F) ▪ Storage temperature: -40 to 85°C (-40 to 185° F) ▪ Relative humidity: 5 to 95% (noncondensing)
Compatibility	Operating System	▪ DOS version 2.11 or higher
Software	Libraries	▪ Microsoft C compatible ▪ Lattice C Compatible
	Media	▪ Both 5.25” and 3.5” (720K) provided
	Disk Space Usage	▪ 100k
	Source Code	▪ Contact your local Allen-Bradley Sales Office to order cat. no. 6008-SIDC ▪ Contact your local Allen-Bradley Sales Office for third party software

Remote I/O	Maximum I/O Configuration	▪ 1,024 discrete inputs ▪ 1,024 discrete outputs ▪ 16 physical I/O adapter devices
	I/O Link Cable Length & Data Transmission Rate	▪ 5,000 cable feet @ 115.2k bits/s ▪ 10,000 cable feet @ 57.6k bits/s
	I/O Scan Single-Transfer Time	▪ 7ms/rack (nominal @ 115.2k bits/s) ▪ 10ms/rack (nominal @ 57.6k bits/s)
	I/O Scan Block-Transfer Time	▪ Block-transfer overhead: ▪ 5ms for either rate ▪ Time per word: ▪ 0.2ms @ 115.2k bits/s ▪ 0.3ms @ 57.6k bits/s
	Adapter Devices Available	▪ Remote I/O Adapter Module (cat. no. 1771-ASB) ▪ Single-Point I/O Adapter Assembly (cat. no. 1771-JAB) ▪ PLC®-5 Processor Module in adapter mode (cat. no. 1785-LT, -LT2, -LT3) ▪ PLC-5/250 Remote Scanner I/O link port in adapter mode (cat. no. 51 50-RS2) ▪ Direct Communication Module (cat. no. 1771-DCM) ▪ PLC Interface Module (cat. no. 3500-NA1) for digital AC and DC drives (1352 and 3450) ▪ Remote I/O Adapter (cat. no. 1336-MOD-G2) for adjustable frequency drives (1336) ▪ Serial Port Connector (cat. no. MOD-S1) ▪ RediPANEL TM Pushbutton and Keypad Modules (bulletin 2705) ▪ PanelView™ (bulletin 2711) ▪ Option Module (cat. no. 1 784-F30D) for the T30 Plant-Floor Terminal (cat. no. 1 784-T30A, -T30C, -T30G) ▪ 8600 CNC with remote I/O adapter option (cat. no. 8600-2085K) ▪ CVIM TM set for adapter mode (cat. no. 5370-CVIM)

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